

FORM PTO-1390
(REV 10-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

821-35

TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/856223

INTERNATIONAL APPLICATION NO.
PCT/SE99/02127INTERNATIONAL FILING DATE
November 19, 1999PRIORITY DATE CLAIMED
November 19, 1998

TITLE OF INVENTION A METHOD AND A DEVICE FOR DEFORMATION OF A MATERIAL BODY

APPLICANT(S) FOR DO/EO/US LARS TROIVE AND YNGVE BERGSTRÖM

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

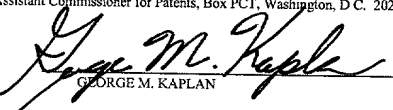
1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☒ is attached hereto (required only if not communicated by the International Bureau). (WO00/30788)
 - b. ☒ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:

4 SHEETS OF FORMAL DRAWINGS, FORM PCT/IPEA/409

CERTIFICATION UNDER 37 C.F.R. § 1.10

I hereby certify that this correspondence and the documents referred to as enclosed are being deposited with the United States Postal Service on date below in an envelope as "Express Mail Post Office to Addressee" Mail Label Number EL820507500US addressed to Assistant Commissioner for Patents, Box PCT, Washington, D.C. 20231.Dated: MAY 18, 2001

 GEORGE M. KAPLAN

09/856223

JC18 Rec'd PCT/PTO 1 8 MAY 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Lars Troive et al.

Examiner:

Serial No.: PCT/SE99/02127

Group Art Unit:

International

Filing Date: November 19, 1999

Dated: May 18, 2001

For: A METHOD AND DEVICE
FOR DEFORMATION OF
A MATERIAL BODY

Docket : 821-35

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir:

Please enter the following Preliminary Amendment in the above-identified

application:

IN THE CLAIMS:

Amend Claims 3, 5, 6, 8-14, 16 and 19-21 as found on the appended

pages.

REMARKS:


The claims in the application are 1-22.

Favorable consideration of the application as amended is respectfully
requested.

CERTIFICATION UNDER 37 C.F.R. § 1.10

I hereby certify that this New Application Transmittal and the documents referred to as enclosed therein are being deposited with the United States Postal Service on this date May 18, 2001 in an envelope as "Express Mail Post Office to Addressee" Mail Label Number EL820507500US addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231.

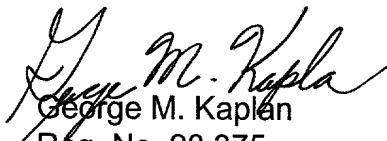
Date: May 18, 2001


George M. Kaplan

The claims have been amended to eliminate all multiple dependencies (a marked-up copy of the claims is enclosed).

Early favorable action is earnestly solicited.

Respectfully submitted,
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Claims

1. A method for deformation of a material body (1), in which a stamping member (2) with a mass m is conveyed towards and hits the material body (1) with such a velocity that at least one rebound motion of the stamping member (2) is generated, while a permanent deformation of the body is generated, **characterized** in that the rebound motion is counteracted, through which at least one additional impact of the stamping member (2) against the material body (1) is generated within a period, during which kinetic energy in the material body (1) generates an additional deformation in the body.
2. A method according to claim 1, **characterized** in that during the period, within which kinetic energy in the material body (1) generates the additional deformation in the body, a reciprocating wave appears through at least a part of the body, the wave motion having the kinetic energy generating the additional deformation.
3. A method according to claim 1 ~~or 2~~, **characterized** in that the rebound motion is counteracted in that a force(F) is allowed to act on the stamping member (2) in the direction towards the material body (1).
4. A method according to claim 3, **characterized** in that the direction in which the stamping member (2) hits the material body (1) is such that the force F comprises at least a part of the gravity force ($m \cdot g$) acting on the stamping member (2).
5. A method according to claim 3 ~~or 4~~, **characterized** in that the force(F) comprises a force(F_1), which is applied to the stamping member (2) in the direction towards the material body (1).

6. A method according to ~~any of claims 1-5~~, **characterized** in that a series of impacts is applied by means of the stamping member (2) against the material body (1) within said period.

5 7. A method according to claim 6, **characterized** in that the series of bounces is achieved in that a corresponding series of rebounds of the stamping member (2) is counteracted.

10 8. A method according to claim 6 ~~or 7~~, **characterized** in that the impulse, with which the stamping member (2) hits the material body (1) decreases with each impact in said series.

15 9. A method according to ~~any of claims 6-8~~, **characterized** in that after a first series of impact, at least one additional series of impacts is applied to the material body (1).

20 10. A method according to ~~any of claims 1-9~~, **characterized** in that the stamping member (2) is caused to accelerate towards the material body (1) under the influence of the gravity force.

25 11. A method according to ~~any of claims 1-10~~, **characterized** in that the material body (1) is a solid body comprising a metal material.

30 12. A method according to ~~any of claims 1-11~~, **characterized** in that said deformation comprises a reshaping of the body.

35 13. A method according to claim 11 ~~or 12~~, **characterized** in that the additional deformation comprises a gradual activation of sliding planes in the material body (1).

14. A method according to ~~any of claims 1-13~~, **characterized** in that the material body (1) comprises a powder, provided in a mold.

15. A method according to claim 14, **characterized** in that plastic deformation of the powder body comprises a compacting thereof.

5 16. A method according to claim 14 ~~or 15~~, **characterized** in that a reciprocating wave appears in the body during said period, which has a kinetic energy generating a mutual displacement of powder grains, such that a compacting is achieved.

10 17. A device for deformation of a material body (1), comprising a stamping member (2) arranged to be conveyed towards and hit a material body (1) with such a velocity that a rebound motion of the stamping member (2) is generated, while a deformation of the material body (1) is generated, **characterized** in
15 that it comprises means (3) for counteracting the rebound and for generating at least one additional impact of the stamping member (2) against the material body (1) within a period, during which kinetic energy in the material body (1) generates an additional deformation in the body.

20 18. A device according to claim 17, **characterized** in that during the period, within which kinetic energy in the material body (1) generates an additional deformation of the body, a reciprocating wave appears through at least a part of the material body
25 (1), the wave motion having the kinetic energy which gradually generates the additional deformation.

19. A device according to claim 17 ~~or 18~~, **characterized** in that the path of motion of the stamping member (2) towards the
30 material body (1) is such that the body is accelerated under the influence of the gravity force acting on it and the rebound is counteracted by the gravity force ($m \cdot g$).

20. A device according to ~~any of claims 17-19~~, **characterized**
35 in that it comprises means (3) for application of a force (F_1) to

21. A device according to ~~any of claims 17-20~~, **characterized**
5 in that it is arranged to perform a series of impacts by means of
the stamping member (2) against the material body (1) within
said period.

22. A device according to claim 21, **characterized** in that the
10 impulse, with which the stamping member (2) hits the material
body (1), decreases with each impact within said series.

5

A method and a device for deformation of a material body

10 BACKGROUND OF THE INVENTION AND PRIOR ART

15 The present invention is related to a method for deformation of a material body, in which a stamping member with a mass m is conveyed towards and hits a material body with such a velocity that at least one rebound motion of the stamping member is generated, while a permanent deformation of the body is generated. The invention also relates to a device for deformation of a material body, comprising a stamping member arranged to be conveyed towards and hit a material body with such a velocity

20 that a rebound motion of the stamping member is generated, while a permanent deformation of the material body is generated.

25 Through the earlier patent application No. WO 97/00751 of the applicant it is known to fix a material body, either in solid form or in form of a powder of grain, pellets or similar and with one single or several consecutive strokes by means of a striking unit achieve adiabatic coalescence in the material body, through which a fast and effective deformation of the material body is

30 obtained.

35 According to this prior art, when a plurality of consecutive strokes is applied to the body, the interval between the consecutive strokes should be smaller than approximately 0,2 seconds. At compacting of powder, preferably metal powder, it is suggested that three consecutive strokes are applied to the

material body. Of these strokes, the first one is an extremely light stroke forcing the most of the air out of the powder and orientating the powder particles. The next stroke has very high energy and high striking velocity in order to achieve local adiabatic coalescence of the powder particles so that these are pressed together to extremely high density. The third stroke has medium high energy, i.e. lower energy than the second stroke, and achieves final shaping of the material body, which subsequently can be sintered. At corresponding deformation of a solid metal body, sliding planes will be activated during a large local temperature increase in the material, through which the required deformation is achieved.

In both the described cases, however, a very powerful impulse from the striking unit will be required to achieve the intended deformation effect when one single stroke or several strokes at intervals of in the order 200 ms are used to achieve the desired goal. The striking tool, or the stamping member, is allowed to bounce back between every single stroke. It is thereby not in contact with the material body between the strokes, only once per stroke. The stroke or the strokes give a locally very powerful increase of the temperature in the material of the deformed body. When the material of the body comprises one or several metals or metal alloys, such a powerful temperature increase usually results in phase transitions of the material, both when heating it and subsequently cooling it. The cooling can further often be done relatively fast, since the temperature increase often is local and the heat can be carried off via the surrounding, colder material. The probability is high that unwanted structures and phases, for instance martensite in steel, are obtained as a result of this process.

SUMMARY OF THE INVENTION

An object with the present invention is to provide a method, by means of which a deformation of a material body of the initially

mentioned kind is performed with as low a temperature increase in the material body as possible while still achieving a satisfactory deformation of the material body. Thereby the method should to a great extent enable the emergence of disadvantageous phases and structures in the material body due to too strong temperature variations in it.

The inventor has at practical experiments discovered that reciprocating waves are generated in the material body at the moment when the stamping member bounces back from the material body. These waves define a kinetic energy in the material body, which energy gradually, in sequences, activates planes in the body and probably also causes mutual displacements of grain of a powder while said waves fast subside. Attempts have been made with material bodies of steel, placed on a base and deformed by means of a stamping member, which has hit these vertically from above. In connection with that it has been noted that the reciprocating waves move forth and back essentially in the impact direction of the stamping member, i.e. from the surface of the material body hit by the stamping member to the surface which abuts against the base and back. At such test material bodies of steel, said waves subside so much that they no longer generate any considerable deformation in the material within a few milliseconds.

The object of the invention has been achieved by means of a method of the initially mentioned kind, which is characterized in that the rebound motion of the stamping member is counteracted, through which at least one additional impact of the stamping member against the material body is generated within a period, during which kinetic energy in the material body generates an additional deformation in the body. The at least one additional impact thereby supplies energy to the material body to such an extent that it contributes to the kinetic energy of the reciprocating wave, through which an additional deformation of the body achieved by said wave continues during a longer pe-

riod than if not any immediate return impact of the stamping member has been performed. The additional deformation achieved by the wave can comprise only sliding plane activation, and/or mutual displacements of grain in the case of a powder
5 body. The additional impact, having a certain impulse and supplying a certain energy, will, thanks to the additional deformation established by the wave, further plastically deform the body. A substantially smaller impulse is required for a given deformation at this time, when more sliding planes are acti-
10 vated, than would have been the case if the additional impact had been applied at a later occasion, when said wave had already subsided.

The inventor has discovered that a lower total energy needs to
15 be supplied to the material body and that a comparatively low temperature increase in the material body can be achieved while still achieving the desired deformation of the material body by means of the method according to the invention.

20 According to a preferred embodiment of the method according to the invention, a series of impacts is applied by means of the stamping member against the material body within said period. Through a series of fast impacts, the material body is continuously supplied kinetic energy which contributes to keeping the
25 reciprocating wave alive and consequently favours further generation of the additional deformation in the material body at the same time as each new impact generates an additional plastic, permanent deformation of the body. The series of impacts is achieved in that a corresponding series of rebounds of the
30 stamping member is counteracted and a new respective impact is achieved, which in its turn generates a new rebound. Every impulse, with which the stamping member hits the material body is consequently large enough to generate a rebound of the stamping member within said series. When several consecutive
35 strokes are applied against the material body for deformation of it, said series of impacts is applied in direct connection with the

respective stroke. The stroke defines the first impact in the respective series of impacts.

According to a further preferred embodiment the impulse, with which the stamping member hits the material body, decreases with each impact within said series. When a stroke only comprising two impacts, a first and a second one, is applied against the material body, the first impact has a larger impulse than the second. Thanks to the effect of the wave on the material body, such a large impulse from the second impact is no longer necessary to generate a certain desired additional plastic deformation. Also in practice it becomes easier to achieve a second impact with a smaller impulse than the first impact within such a short period of time here referred to (approximately 1 ms), for instance by effective damping of the rebound motion. The possibility to apply a second impact with a larger impulse than the first or previous impact shall however not be excluded, if required.

According to another preferred embodiment the material body is a solid body comprising a metal material, said deformation comprising a reshaping of the body. The additional deformation is thereby done in that the kinetic energy of the reciprocating wave generates a gradual activation of sliding planes in the material body. Since the sliding planes are activated gradually, a slower and less intense deformation of the material can be achieved by the application of one or several additional impacts besides the first against the material body. The temperature increase in the material body hereby does not need to be as large as when a corresponding deformation of the body shall be achieved by means of one single impact, after which the reciprocating wave in the material body is allowed to subside without any additional energy being supplied hereto from outside.

According to a further preferred embodiment the material body comprises a powder, provided in a mould. The deformation of

the powder body comprises a compacting thereof. The method according to the invention offers a fast and effective way of compacting powder, for instance cemented carbide powder, without any unnecessarily high temperatures, which could lead to forming of undesired structures and/or phases being generated in the powder. As mentioned above, the prior art suggests that the powder material body is compacted in three steps, a first step when a light stroke is applied against the body in order to achieve an initial orientation of the powder particles, a second step when a very powerful stroke is directed against the powder to achieve local adiabatic coalescence of the powder particles so that these are pressed together to high density, and a third step, at which a stroke of medium high energy is applied against the powder body and a final forming takes place. The method according to the invention could with advantage be applied at the second step and/or possibly at the third step.

A further object of the invention is to provide a device, by means of which it is possible to work a material body by means of a stamping member hitting the material body with such an impulse that an adiabatic coalescence is obtained in the material body, at which a minimum temperature increase is achieved in the body at the same time as the deformation aimed at is obtained.

This object is obtained by means of a device of the initially defined kind, characterized in that it comprises means for counteracting the rebound and for generating one additional impact of the stamping member against the material body within a period, during which kinetic energy in the material body generates an additional deformation herein.

According to a preferred embodiment, the path of motion of the stamping member towards the material body is such that the body is accelerated under the influence of the gravity force acting on it and the rebound is counteracted by the gravity

force. Thereby the own mass of the stamping member can be used for generating the additional impact directed against the body. Preferably the stamping member is allowed to drop substantially vertically in the direction of the material body, through which the gravity force is used maximally to counteract the rebound of the stamping member.

According to a further preferred embodiment, the device comprises means for application of a force F_1 to the stamping member, which force acts in the direction towards the material body and counteracts the rebound. By a suitable choice of the mass of the stamping member, the drop and the size of the force F_1 applied it is consequently possible to control the time between two consecutive impacts of the stamping member against the material body. The applied force F_1 not only counteracts the rebound but also contributes to actively pushing the stamping member in the direction towards the material body.

According to a further preferred embodiment, the device is arranged to perform a series of impacts by means of the stamping member against the material body within said period. Every single impact thereby takes place with such a velocity of the stamping member that a following rebound of it is generated. The device can thereby comprise means for controlling the size of the force applied on the stamping member, for instance so that it gradually subsides with every additional rebound in order to achieve a harmonic and not too fast a damping of the motions of the stamping member against the material body.

According to a further preferred embodiment, the impulse, with which the stamping member hits the material body, decreases with each impact within said series. Above all the difference in impulse between the first impact and the second impact is large. The respective impulses contribute to preventing the reciprocating wave in the material body from subsiding too fast. In this manner energy is supplied in the form of kinetic energy to the

material body within a period, during which the kinetic energy in the most effective way generates a deformation in the material body. As mentioned above, the additional deformation generated by the wave in the body comprises activation of sliding planes. Each additional impact within said period benefits therefrom for generating an additional plastic deformation of the material body while said sliding planes are still activated.

Further characteristics and advantages of the invention will be apparent from the following description and from the other patent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will hereinafter be described for exemplifying purposes with reference to the enclosed drawings, in which;

Fig 1 is a schematic cross-sectional view from the side, showing a device for deformation of a solid body,

Fig 2 is a schematic cross-sectional view from the side, showing a similar device for compacting of a powder,

Fig 3 is a diagram schematically showing a registered displacement of a stamping member according to Fig 1 or 2 in time,

Fig 4 is a diagram schematically showing the axial velocity of the stamping member and a surface of the material body respectively, according to Fig 1 in time,

Fig 5 is a diagram showing, in an experiment with powder compacting, both the motion of the stamping member in time and the force with which the stamping member influences the powder material during the course of compacting,

Fig 6 is a diagram describing the position of the stamping member as function of time at deformation (forming) of a solid body, and

- 5 Fig 7 is an enlargement of the third forming step evident from Fig 6.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

- 10 In Figs 1 and 2 a device for deformation of a material body 1 is shown schematically. The device comprises a stamping member 2, arranged to be conveyed towards and hit the material body 1 with such a velocity that a rebound motion of the stamping member 2 is generated. Thereby the material body 1 is de-
15 formed.

The material body in Fig 1 is formed by a material in solid form, preferably a solid metal. In Fig 2 the material body 1 is formed by a powder preferably already being lightly compacted, either
20 by means of a light stroke of the stamping member or some other similar member. The device is arranged to achieve an immediate and relatively large deformation of the material body 1 by means of a powerful stroke of the stamping member.

- 25 The stamping member 2 is so provided that it under influence of the gravity force acting on it is accelerated towards the material body 1. The mass m of the stamping member 2 is preferably substantially larger than the mass of the material body 1. Thereby the need for a high impact velocity of the stamping
30 member 2 can be reduced somewhat. The stamping member 2 is allowed to hit the material body 1 with such a velocity that a local adiabatic coalescence and a deformation in the material body 1 associated therewith is obtained. The velocity is furthermore such that a rebound of the stamping member 2 is
35 generated. The deformation of the material body 1 thereby achieved is plastic and consequently permanent. When the

stamping member 2 rebounds, strong waves or vibrations in the material body 1 is generated in the striking direction of the stamping member 2. The waves are initially amplified when the stamping member 2 is not in immediate contact with the material body 1. This wave or these waves have a high kinetic energy and will activate sliding planes in the material body, which have not been activated during the previous impact. During the period, when these sliding planes are activated, the material body 1 will be relatively easier to deform with a given impulse or energy of a next following impact. The device is therefore so provided that a sufficient force acts on the stamping member 2 in the direction towards the material body 1 because an additional impact, with an impulse exceeding a minimum value, is generated against the material body 1 within said period. The period is however very short, in the order of a few milliseconds. If the mass of the stamping member 2 is very large it could in fact be possible to achieve said additional impact within this period by only letting the gravity force act on the stamping member 2 and damp the rebound and accelerate the stamping member 2 against the material body 1.

According to the shown preferred embodiment of the device, the latter however comprises a means 3 for application of a force F_1 on the stamping member 2, which force acts in the direction towards the material body 1 and counteracts the rebound. This means 3 can comprise a force cylinder, for instance a hydraulic cylinder. The purpose of it is not only to counteract the rebound motion of the stamping member 2, but also to accelerate the stamping member 2 towards the material body 1 and thereby contribute to the impulse, with which the stamping member 2 hits the material body 1 at the following impact. Preferably the force F_1 , the moving path of the stamping member 2 and the direction of motion towards the material body 1 and the mass m of the stamping member 2 are adapted so that an additional impact, preferably several additional impacts, each contributing to

extend said period and in steps further plastically deform the material body 1 are generated.

Fig 3 schematically shows the axial displacement of the stamping member 2 in time from the moment when the stamping member 2 hits the material body 1 and starts to deform it to the time, when the wave or waves in the material body have subsided and additional possible rebounds and impacts from the stamping member no longer generate any substantial additional deformation of the material body 1. The diagram is created from a test, at which a stamping member 2 with a mass of 105 kg was used for deforming a cylinder with the height 20 mm and the diameter 12 mm, made of soft annealed bearing steel. By means of a hydraulic piston in addition 50 kN was applied to the stamping member 2 in the direction towards the material body 1, i.e. the steel cylinder.

The velocity, with which the stamping member 2 was allowed to hit the material body 1 was varied at different tests. At the test generating a diagram, approximately corresponding to the diagram of Fig 3, velocities in axial direction of the stamping member 2 was measured and from a calculation model a schematic image over a typical velocity of the material body 1 in axial direction was obtained, which velocities are approximately illustrated in Fig 4. The line a indicates the velocity of the stamping member and line b indicates the velocity of the material body. It is evident how a wave, i.e. a reciprocating motion, is generated in the material body 1 as soon as the rebound motion of the stamping member 2 has begun. This occurs in the illustrated test after approximately 3 ms. One millisecond later, i.e. after 4 ms, the device performs the next impact.

At the impact moment, when the stamping member 2 and the material body 1 are in contact with each other and the material body 1 is deformed under the influence of the impulse of the stamping member 2, the amplitude of the wave in the material

body 1 subsides somewhat, to then increase in size again when the stamping member 2 again bounces back and completely or partly loses contact with the material body 1 for a short moment. The period between two consecutive impacts is in the order of 1 ms. After a certain time, here in the order of 5 ms, the wave in the material body 1 has, however, subsided so much that it no longer contributes to activation of additional sliding planes. Additional impacts from the stamping member 2 will thereby not to any considerable extent contribute to any additional plastic deformation of the material body 1, as long as not any radical measures are taken, for instance a prominent increase of the power, with which the stamping member 2 is influenced. When this stage has been achieved the stamping member can suitably be returned to a position, from which a new, corresponding series of impacts against an additional material body 1 or the same material body 1 is performed.

It should be mentioned that a reciprocating wave can appear in the material body 1 also during the initial plastic deformation of it, i.e. before the rebound motion of the stamping member 2 has been generated, but that this wave has a substantially lower amplitude than when the rebound motion has been generated. For the sake of clarity no reciprocating wave of the material body 1 at the initial deformation thereof is shown in Fig 4.

In Fig 5 the abscissa denotes the time (milliseconds) while the ordinate denotes the motion distance of the stamping member with reference to the graph indicated with 4 while the ordinate refers to force concerning the graph indicated with 7. As previously mentioned, the stamping member describes a rebound motion during a forming step. In the diagram according to Fig 5 the graph 4 shows the motion of the stamping member at the performed experiment with powder compacting. The graph 7 describes the force with which the stamping member influences the powder material being compacted.

From the diagram in Fig 5 it can be seen, with reference to the compacting phase indicated with 6, how the force (the graph 7) in the powder material increases at every rebound of the stamping member, see the graph 4. Further it is evident how the stamping member takes an increasingly lower position after every rebound, see the graph 4, and thereby gives the powder material an increasingly higher degree of compacting. After the motion of the stamping member has subsided, the stamping member sooner or later is manoeuvred up to the parking position according to graph 4. The force according to the graph 7 does not decrease to its original position due to inner friction in the compacting tool itself.

In Fig 6 forming of a solid body with a striking sequence including three strokes is illustrated. In Fig 6 the abscissa indicates the time while the ordinate indicates the motion distance of the stamping member. Consequently, from Fig 6 the position of the stamping member as function of the time can be gathered, acceleration phase, forming phase and upward motion of the stamping being evident for each of the three strokes. In Fig 7, an enlargement of the third forming step (stroke) is illustrated.

The device according to the invention is preferably a striking machine of a type similar to the one described in the previous patent application WO 97/00751 of the applicant. Such a striking machine uses preferably hydraulics to generate the strokes or impacts achieved by means of a stamping member 2 against a material body 1. The device is preferably arranged so that it can perform several consecutive series of impacts of the kind according to the invention with very short mutual time space between the series, respectively.

The invention proposes a very effective and reliable way, in which material bodies, solid as well as more loosely put together from single particles, can be deformed and/or com-

pacted. The energy that a stamping or striking member exhibits when it hits the material body which is to be deformed is used in the best possible way in order to generate as large a deformation as possible in the material body. In addition, the presence of unwanted structures in the deformed material body, arising at large temperature variations in it, are reduced compared to when single strokes or stroke series according to prior art is used to achieve a deformation of it through adiabatic coalescence in the material body.

10

Of course a plurality of alternative embodiments, lying within the scope of the invention, will be obvious for a man skilled in the art. The idea of the invention shall be interpreted in its widest sense and as defined in the enclosed patent claims with support of the description and the enclosed drawings.

15

Claims

1. A method for deformation of a material body (1), in which a stamping member (2) with a mass m is conveyed towards and hits the material body (1) with such a velocity that at least one rebound motion of the stamping member (2) is generated, while a permanent deformation of the body is generated, **characterized** in that the rebound motion is counteracted, through which at least one additional impact of the stamping member (2) against the material body (1) is generated within a period, during which kinetic energy in the material body (1) generates an additional deformation in the body.
2. A method according to claim 1, **characterized** in that during the period, within which kinetic energy in the material body (1) generates the additional deformation in the body, a reciprocating wave appears through at least a part of the body, the wave motion having the kinetic energy generating the additional deformation.
3. A method according to claim 1 or 2, **characterized** in that the rebound motion is counteracted in that a force F is allowed to act on the stamping member (2) in the direction towards the material body (1).
4. A method according to claim 3, **characterized** in that the direction in which the stamping member (2) hits the material body (1) is such that the force F comprises at least a part of the gravity force ($m \cdot g$) acting on the stamping member (2).
5. A method according to claim 3 or 4, **characterized** in that the force F comprises a force F_1 , which is applied to the stamping member (2) in the direction towards the material body (1).

6. A method according to any of claims 1-5, **characterized** in that a series of impacts is applied by means of the stamping member (2) against the material body (1) within said period.

5 7. A method according to claim 6, **characterized** in that the series of bounces is achieved in that a corresponding series of rebounds of the stamping member (2) is counteracted.

10 8. A method according to claim 6 or 7, **characterized** in that the impulse, with which the stamping member (2) hits the material body (1) decreases with each impact in said series.

15 9. A method according to any of claims 6-8, **characterized** in that after a first series of impact at least one additional series of impacts is applied to the material body (1).

20 10. A method according to any of claims 1-9, **characterized** in that the stamping member (2) is caused to accelerate towards the material body (1) under the influence of the gravity force.

11. A method according to any of claims 1-10, **characterized** in that the material body (1) is a solid body comprising a metal material.

25 12. A method according to any of claims 1-11, **characterized** in that said deformation comprises a reshaping of the body.

30 13. A method according to claim 11 or 12, **characterized** in that the additional deformation comprises a gradual activation of sliding planes in the material body (1).

14. A method according to any of claims 1-9, **characterized** in that the material body (1) comprises a powder, provided in a mould.

15. A method according to claim 14, **characterized** in that plastic deformation of the powder body comprises a compacting thereof.

5 16. A method according to claim 14 or 15, **characterized** in that a reciprocating wave appears in the body during said period, which has a kinetic energy generating a mutual displacement of powder grains, such that a compacting is achieved.

10 17. A device for deformation of a material body (1), comprising a stamping member (2) arranged to be conveyed towards and hit a material body (1) with such a velocity that a rebound motion of the stamping member (2) is generated, while a deformation of the material body (1) is generated, **characterized** in
15 that it comprises means (3) for counteracting the rebound and for generating at least one additional impact of the stamping member (2) against the material body (1) within a period, during which kinetic energy in the material body (1) generates an additional deformation in the body.

20 18. A device according to claim 17, **characterized** in that during the period, within which kinetic energy in the material body (1) generates an additional deformation of the body, a reciprocating wave appears through at least a part of the material body
25 (1), the wave motion having the kinetic energy which gradually generates the additional deformation.

19. A device according to claim 17 or 18, **characterized** in that the path of motion of the stamping member (2) towards the
30 material body (1) is such that the body is accelerated under the influence of the gravity force acting on it and the rebound is counteracted by the gravity force ($m \cdot g$).

20. A device according to any of claims 17-19, **characterized**
35 in that it comprises means (3) for application of a force F_1 to

the stamping member (2), which force acts in the direction towards the material body (1) and counteracts the rebound.

21. A device according to any of claims 17-20, **characterized**
5 in that it is arranged to perform a series of impacts by means of the stamping member (2) against the material body (1) within said period.

22. A device according to claim 21, **characterized** in that the
10 impulse, with which the stamping member (2) hits the material body (1), decreases with each impact within said series.

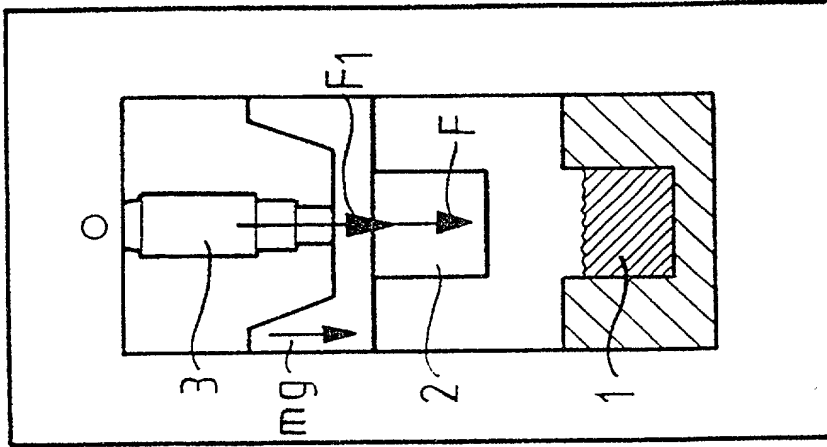


FIG 2

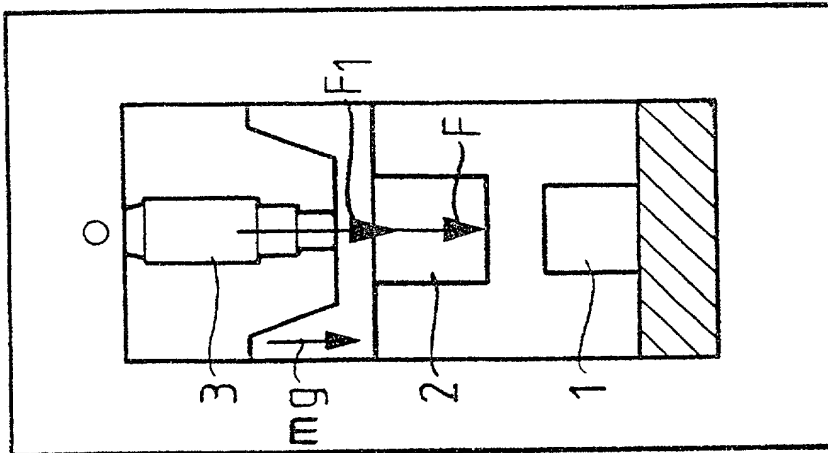
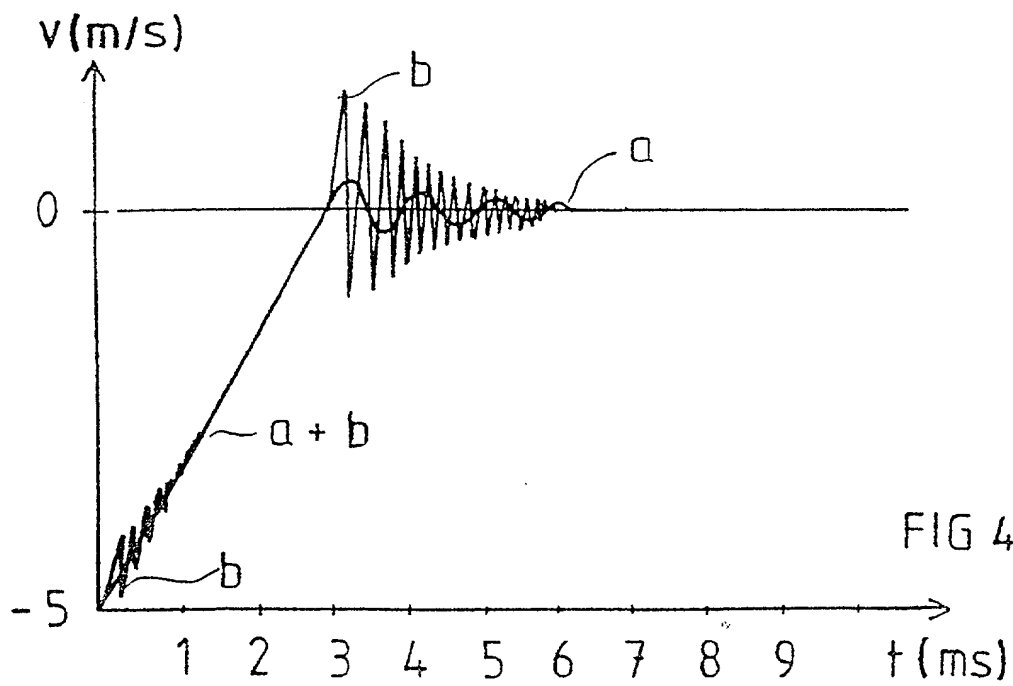
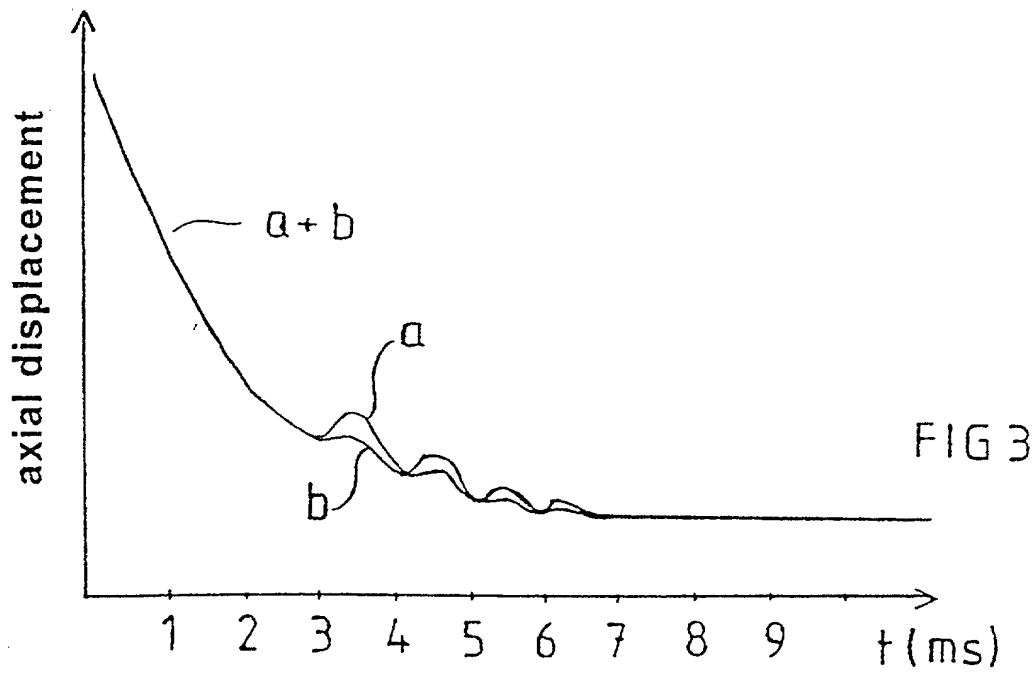
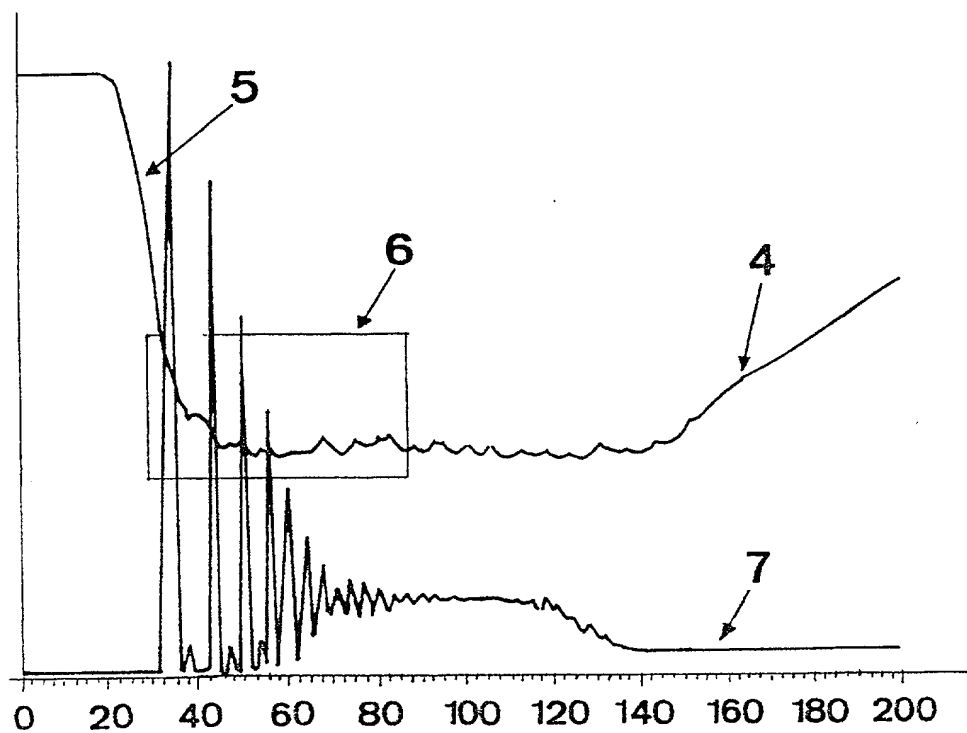
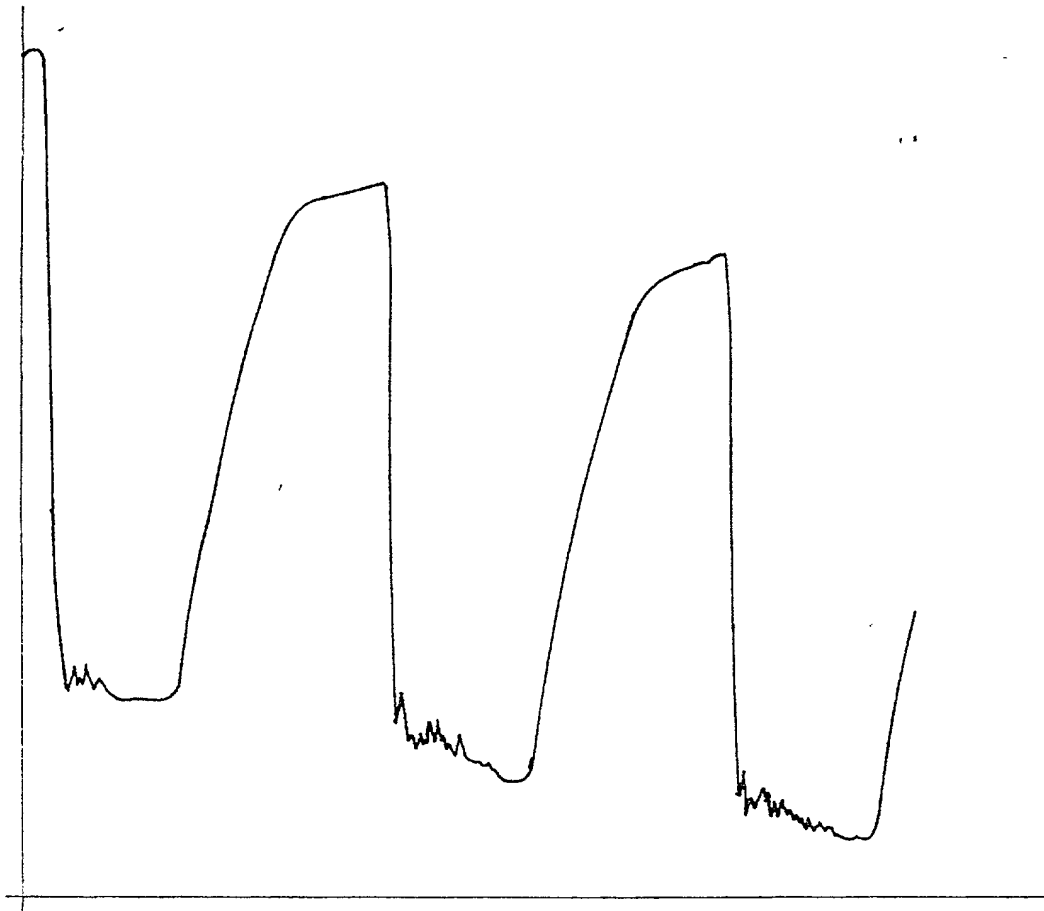
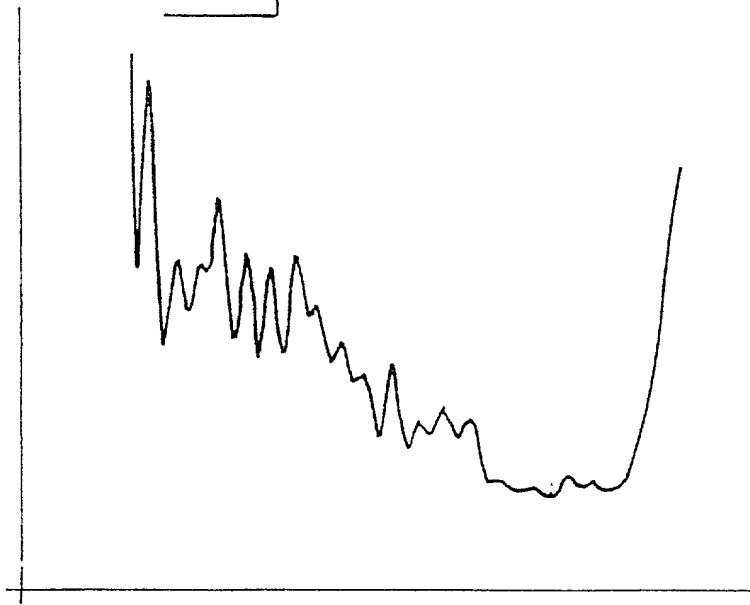


FIG 1



Fig 5

Fig 6Fig 1

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
 (includes Reference to PCT International Applications)

Attorney's docket No.

As a below named inventor, I hereby declare that

My residence, post office address and citizenship are as stated below next to my name

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"A method and a device for deformation of a material body"

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application.

Serial No. _____

on _____

and was amended

on _____ (if applicable).

☐ was filed as PCT international application

Number PCT/SE99/02127

on November 19, 1999

and was amended under PCT Article 19

on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT indicate PCT)	APPLICATION NO.	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. 119
Sweden	9803956-3	November 19, 1998	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

Combined declaration for patent application and power of attorney (continued)
(includes Reference to PCT International Applications)

Attorney's docket No

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS		STATUS (Check one)		
APPLICATION NO	U.S. FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.				
APPLICATION NO.	FILING DATE	US SERIAL NO. ASSIGNED (if any)		

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number).

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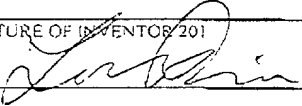
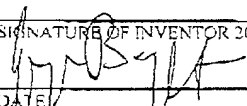
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RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201 	SIGNATURE OF INVENTOR 202 	SIGNATURE OF INVENTOR 203
DATE Boston 2001-08-31	DATE Boston 2001-08-31	DATE